CLA-REWG Paper on setting MRLs in Honey for pesticides originating from Application of Plant Protection Products to Plants
DRAFT
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Recent concerns on the effects of pesticides on bee hive health and vitality have led to increased monitoring of bee products for pesticides and other contaminants. The presence of trace amounts of pesticides in honey has been publicized extensively. Although the majority of the concern has been focused on the health of the honey bees, not consumers, pesticide residues in consumable products such as honey need to be evaluated for dietary safety for adults, children and infants. Moreover, honey is a highly traded commodity, therefore the presence of trace amounts of pesticide residue, though considered safe for human consumption, must be managed by established MRLs to facilitate trade and support the growth of small-scale and large-scale beekeeping for honey production.

1. Objective

The objective of this document is to propose a tiered regulatory approach for setting tolerances or MRLs (maximum residue levels) for pesticides in honey. This US tolerance will be used to assess consumer safety based on US consumption information and would be available as a trading standard to support international trade.

2. Background

There is a complex biological process in nature which starts with photosynthesis and the harnessing of the sun's energy to create simple sugars, which are metabolized and stored by plants, harvested by honey bees, carried back to the hives, metabolized and stored again as fuel for the colony and finally harvested by people to sweeten our desserts and enhance our lives. This document proposes a reasonable, yet appropriately conservative procedure for assessing the human safety of honey with regard to potential pesticide residues which may be transferred from treated crops to honey as part of this beneficial process.

3. Scope

In addition to honey, honey bees also produce wax, pollen loads, propolis, bee bread and royal jelly, which may be collected for human use and consumption, but in very low amounts. Honey remains the main bee product used as human food. Because honey is a sweetener, not a staple food product, the daily average personal consumption in the US is quite low and represents a very small part of the total diet. On average, people in the US (total population) consume only 0.015 μg/kg bw/day and children age 1-2 consume on average 0.036 μg/kg bw/day according to the 2005-2010 NHANES survey.

Pesticide residues have potential to end up in honey from different sources. The source most likely to lead to measureable residue in honey is direct application of pest products such as miticides to the bee hive or surrounding structure. There is a process already in place for establishing MRLs in honey for these uses. Pesticide residues could also potentially be transferred to honey in the nectar and pollen which the bees bring back from treated plants in their foraging area. Inadvertent pesticide residues in honey from this source are expected to be much lower in magnitude, when present at all. This document addresses only residues from this second scenario.

4. Tiered approach

As with many situations where the consumer is exposed only to minimal risk under infrequent or unlikely circumstances, a tiered approach, which assumes at first a worst-case estimate, followed by refinement based on more realistic or experimental data, is both a conservative and efficient method, which adequately addresses risk for consumers. In this case, a tiered approach is optimal, since **even worst-case estimates are not likely to lead to an unacceptable risk for any consumer groups from consumption of honey.**

- The first step in the proposed approach involves identifying the situations where pesticide residues are likely to transfer to honey. Only certain crops are frequented by domestic or wild honey bees. The USDA table summarizing attractiveness of agricultural crops to pollinating bees for the collection of nectar and pollen is included in attachment 4.

- In addition, the application timing of the pest product must lead to residues during the critical flowering stages of the plant for residues to be picked up by foraging bees. The product use for these crops and timings must be supported by the registrant.

- Finally, residues must be stable in the honey comb (a warm, acidic environment). Honey bees maintain the temperature of the brood nest between 32°C and 35°C. The acidity of honey ranges from 3.4 to 6.1. The physio-chemical properties of the active ingredient and its relevant metabolites should be taken into account when considering if a situation exists for the transfer and subsequent occurrence of measurable amounts of pesticide residues in honey.

- Once it is established that a situation does offer a potential for residues to occur in honey, a conservative worst-case estimate for potential residue levels in honey can be proposed as a "threshold MRL". If this threshold MRL passes the US acute and chronic dietary risk assessment based on the toxicological endpoints of the specific active ingredient, then no further evaluation is required and no label restrictions are needed to address this issue.

  The proposed threshold MRL for honey is based on the current available monitoring data in honey. Residue data from a special PDP program focused on honey are available from 2007 and 2008. Over both years, a total of 744 samples were analyzed for 164 pesticides or pesticide metabolites. In 2007, six residues were detected in the 186 samples that were

analyzed. Two of these pesticides are currently registered for direct use on hives. The maximum value of any single pesticide, precluding those registered for direct use on hives, was 27.5 ppb. In the 2008 program, monitoring was more extensive (558 samples were analyzed), and there were 12 pesticide residues detected. Two of these pesticides are registered for use on hives. Two others have MRLs established for food handling uses. In these samples the maximum residue value detected was 90 ppb of dicofol, but the average residue value of dicofol in the 32 honey samples with detectable residues was 5.1 ppb. Collectively, these data support an MRL at the threshold of 0.1 mg/kg in honey. This value is consistent with the findings in the FDA monitoring program, where only one compound was detected above this value during the program years of 2004 through 2012 out of the 456 honey samples that were analyzed. This value is also congruent with the existing general Canada default MRL of 0.1 mg/kg as well.

- If the threshold MRL for honey does not pass the dietary risk assessment, or if further refinement is desired for other reasons, the next step in the tiered approach is to determine a custom honey MRL from monitoring data, if they are available. If the pesticide has been included in one of the monitoring programs which includes honey (PDP or FDA monitoring program), the recorded residue values (detectable values as well as non-detectable values) can be used as inputs for the OECD calculator to estimate the 95th percentile residue value and appropriate MRL.

- If monitoring data are insufficient, residue trials can be conducted to generate more refined experimental values. In lieu of residue trials which generate results for honey, however, residue values can be considered from the flowering parts of plants (flowers, nectar and/or pollen) as a worst case conservative estimate for residues in honey. While it is known that foliar application of pesticides tend to result in significant residue levels in flowers and pollen (somewhat less so in nectar), early pre-bloom applications may lead to very low or non-quantifiable residues in the flowering parts of plants even if the compound is systemic. Data have shown that a transfer factor of 1.0 from flowers to honey should be considered as conservative worst-case assumption compared to data available in the literature (values from 0.0065 to 0.25, Kubik *et al*, 1999). These residue field studies can be conducted following the typical OECD Field Trial guideline 509, although the critical GAP of the product must be defined relative to exposure to honey bees instead of the consumable commodity. The shortest allowable PHI or latest growth stage for application on the label may not be the most critical timing parameter relative to foraging bees. Label restrictions on application timings or procedures to avoid excessive honey residues may also be appropriate, such as prohibiting application during the blooming period.

- Finally, the last tier available to registrants is to conduct residue trials which produce honey under controlled conditions. Such a study should be conducted under an established guideline such as the OECD guideline for honey bee brood test. The detailed experimental design for such a study should be discussed with the EPA prior to conduct.

In the case that field trials are conducted in either nectar, pollen or honey, the GAP used must represent the reasonable worst case conditions for residues in the aerial part of the plants during flowering that is allowable on the proposed or registered label.

5. Implication of Proposed 0.1 mg/kg Honey Threshold MRL

A general impact assessment of the proposed threshold MRL on existing risk cups was conducted by assessing the dietary exposure resulting from a 0.1 mg/kg residue level in honey relative to the reference doses of 363 pesticides (codified with reported Human Health benchmarks (HHBM) at *http://iaspub.epa.gov/apex/pesticides/f?p=HHBP:home:3176625085585).*

In DEEM (ver 4.02), a value of 0.1 mg/kg MRL in honey results in a chronic exposure of 0.00000362 (3.62×10^{-6}) mg/kg bw/day and acute 95th percentile exposure of 0.00001415 (1.415×10^{-5}) mg/kg bw/day for children ages 1-2, the most sensitive consumer group for honey consumption based on the NHANES 2-day food consumption data for 2005-2010. Although these low exposures will not have a significant impact on most pesticide risk cups, the impact depends upon the chronic and acute reference doses of each pesticide. The chronic and acute dietary reference doses of the 363 pesticides posted on the EPA website for Human Health Benchmarks were assessed against the exposures for honey, assuming a threshold tolerance of 0.1 mg/kg. The results are summarized in the following table:

Table 1. Risk Cup Utilization for 363 compounds in the HHBM database from Residues in Honey at Threshold MRL of 0.1 mg/kg

	Acute at 95%tile	**Chronic**
No. of compounds where honey exposure exceeds the reference dose for children age 1-2	0	1 (0.3%)
No. of compounds where honey exposure is more than 5% of reference dose for children age 1-2*	4 (1%)	10 (3%)
No. of compounds where honey exposure is less than 5% of reference dose for children age 1-2*	235 (65%)	345 (95%)
No. of compounds in HHBM with no reference dose**	124 (34%)	8 (2%)

**Honey exposure at the threshold MRL of 0.1 mg/kg would exceed 5% of the RfD for pesticides with acute RfDs lower than 0.000283 mg/kg bw/day and/or chronic RfDs lower than 0.000073 mg/kg bw/day.*

***Compounds which are not assigned an acute or chronic reference dose generally have demonstrated very low acute or chronic toxicity.*

In general, the vast majority of registered pesticides could accommodate this threshold MRL without any unacceptable consumer risk.

This assessment does not take into account the recent 2015 proposal for an additional 10X FQPA factors for all OPs; however, the majority of compounds with low reference doses below the thresholds are in fact already OPs. In addition, there are 40 compounds within the HHBM

database with cancer considerations, but since they all have different Q* values, a quick benchmark assessment for impact has not been conducted for those compounds.

Below are some example compounds with different endpoints to demonstrate the impact of a 0.1 mg/kg threshold MRL for honey in terms of % of children's risk cup.

Table 2. Impact of 0.1 mg/kg Threshold MRL on Acute and Chronic Dietary Risk for Selected Compounds

Compound	aPAD (mg/kg bw)	cPAD (mg/kg bw/day)	% children's aPAD 95%, 99.9	% children's cPAD
Fipronil	0.025	0.0002	0.06, *1.10*	1.8
Imidacloprid**	0.14	0.057	0.1, *1.96*	<0.1
Boscalid	NA	0.218	-	~0
Pyrethins	0.07	0.044	0.02, *0.39*	<0.1
Cadusafos***	0.00002	0.000001	70.50, *1372.35*	358.1
Coumaphos*	0.0025	0.0003	0.56, *10.98*	1.2
Fluvalinate*	0.005	0.005	0.28,*5.49*	0.1

**registered for direct use on hives*
*** neonicotinoid*
**** No US registration. Previously used directly in hives. Only one import tolerance on bananas.*

6. Systemicity and application growth stage

If metabolism or transfer studies in crops clearly establish that neither the parent active substance nor toxicologically-relevant metabolites are present in a non-treated part of the plant when the pesticide product is applied according to critical GAPs, then it can be considered that the active substance is not systemic.

If such a product is applied at a time when bees are not foraging the crops, then the risk of exposure of bees to residues is low, and the risk of residues in honey can be considered negligible. As a consequence, there should be no need to establish a specific MRL in honey.

Similarly, if an active substance that clearly shows systemic activity is applied after flowering, when bees no longer forage, then the risk of exposure of bees to residues is low and the risk of residues in honey can be considered negligible. Once again, there is no need to establish a specific MRL in honey.

However, if an any active substance is applied during flowering, or if a systemic active substance is applied before flowering and the residue is known to be persistent, then there is a possibility that bees could be exposed to finite residues in nectar or pollen, which could lead to transfer of residues into honey. In these cases, the threshold MRL in honey should be considered.

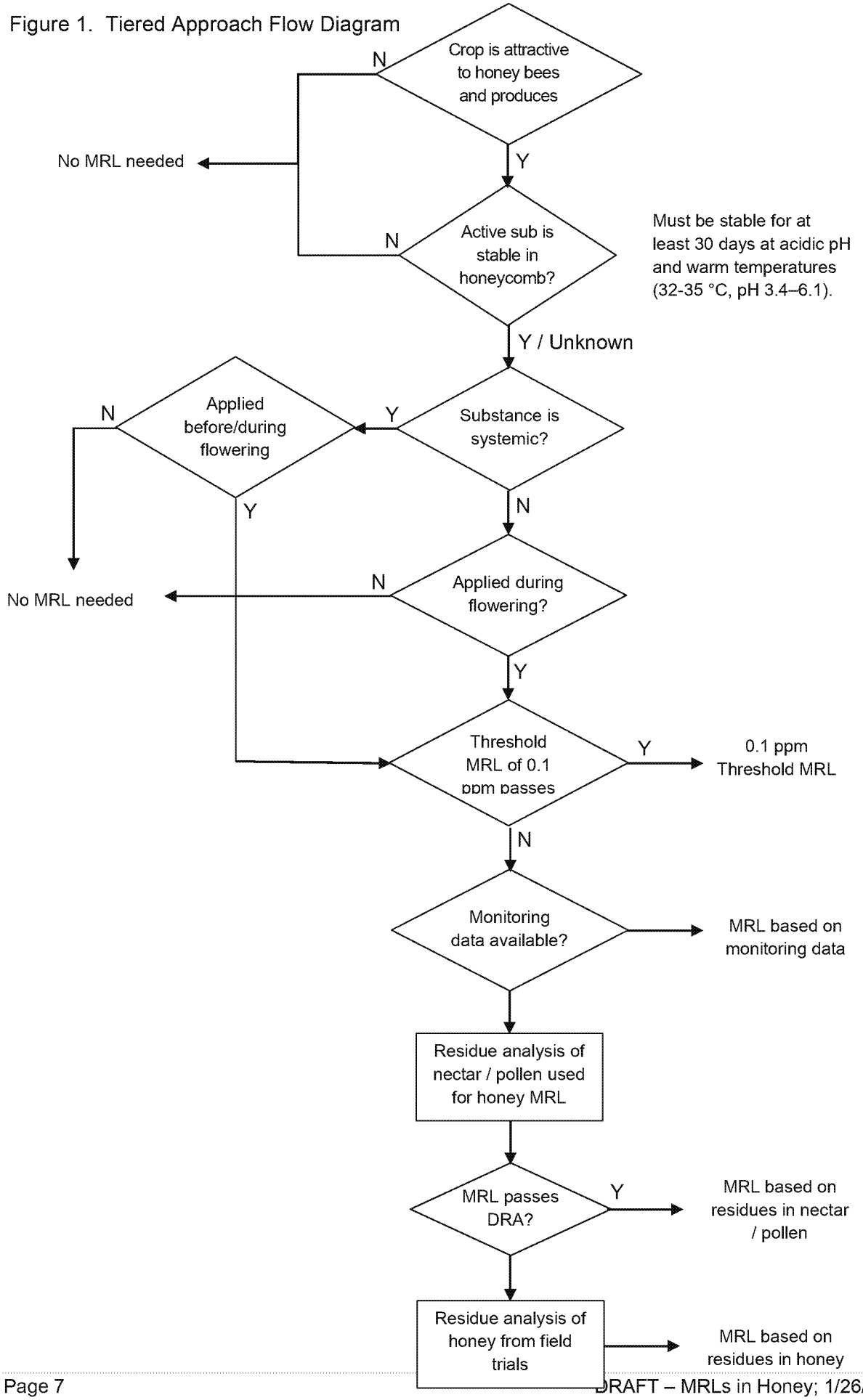
7. Residue Definitions

Honey is made mainly from nectar that is partially modified by the metabolic processes of bees and the subsequent fermentation process in the hive. As a consequence, it appears that a specific residue definition should be established for honey, but as honey consumption has little impact on total dietary exposure, and specific metabolism data are not likely to be available, a pragmatic approach to the residue definition is warranted. In most cases, parent-only residue definition will be sufficient, but this determination must be based on the specific metabolic and toxicological properties of the active ingredient. The residue definition for honey for enforcement and risk assessment should be discussed with the EPA.

8. Continued monitoring and evaluation

This pragmatic approach for MRL setting is based on currently available residue data in honey; however, honey is not routinely included in the PDP. It is recommended that this valuable monitoring program include honey on a regular basis, if justified to continuously evaluate and possibly refine the elements of this tiered approach.

Figure 1. Tiered Approach Flow Diagram



References

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Arnia Remote Hive Monitoring: http://www.arnia.co.uk/temperature-and-thermoregulation-in-the-beehive/

Human Health Benchmarks for Pesticides (EPA): http://iaspub.epa.gov/apex/pesticides/f?p=HHBP:home:3176625085585

OECD Guidelines for the Testing of Chemicals, Test No. 509: Crop Field Trial: http://www.oecd-ilibrary.org/environment/test-no-509-crop-field-trial_9789264076457-en

OECD Guidelines for the Testing of Chemicals: Test No. 75: Guidance Document on the Honey Bee (Apis mellifera L.) Brood Test under Semi-Field Conditions: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2007)22&doclanguage=en

Attachments

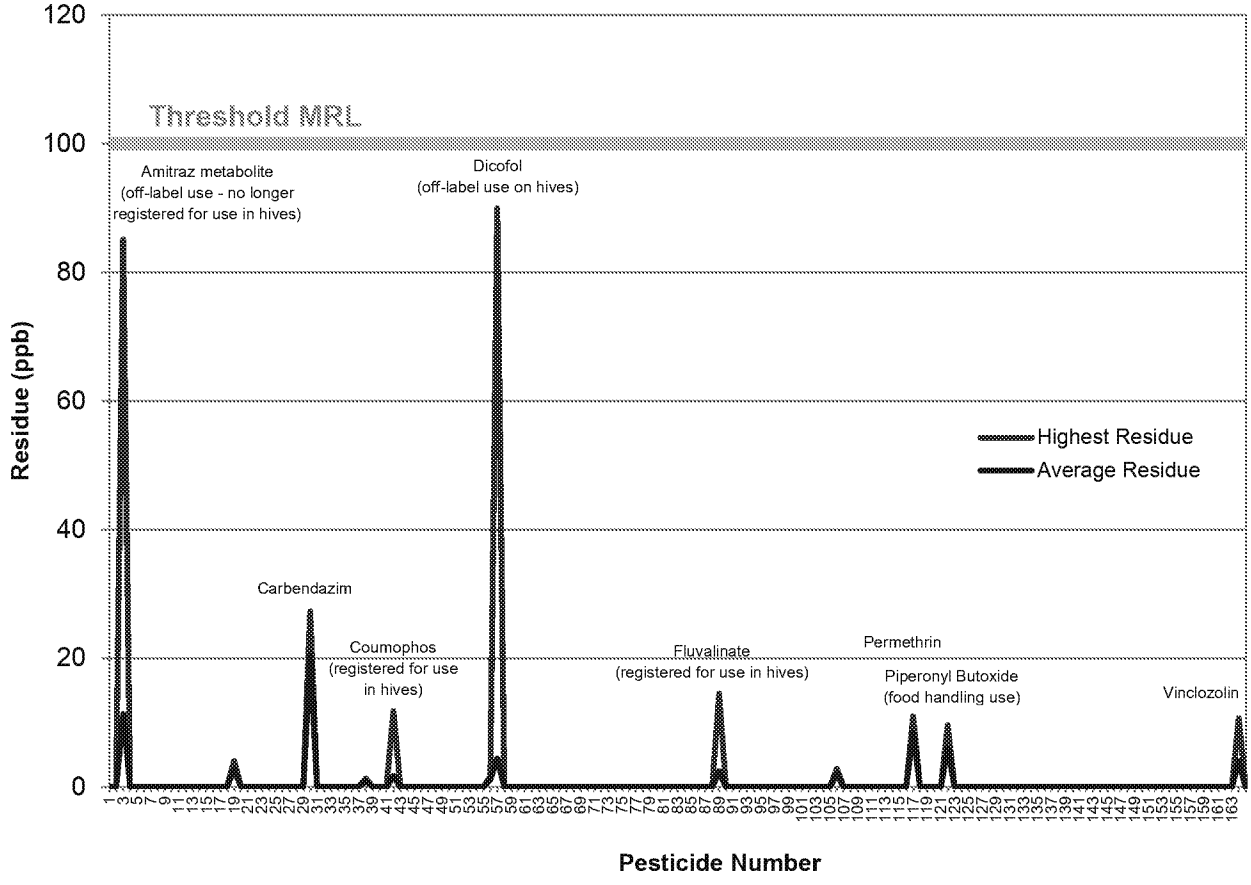
1 – Graph of pesticide residues detected in PDP honey samples from 2007 and 2008 compared to threshold MRL of 0.1 mg/kg.

2 – 2007 Summary of Residue Finding in Honey from all Pesticides *with notations.*

3 - 2008 Summary of Residue Finding in Honey from all Pesticides *with notations.*

4 - USDA tables summarizing attractiveness of agricultural crops to pollinating bees for the collection of nectar and pollen.

Attachment 1. Graph of pesticide residues detected in PDP honey samples from 2007 and 2008 compared to threshold MRL of 0.1 mg/kg.



Appendix D

Distribution of Residues by Pesticide in Honey

Appendix D shows residue detections for all compounds tested in honey, including range of values detected, range of Limits of Detection (LODs), and U.S. Environmental Protection Agency (EPA) tolerance references for each pair.

In 2007, PDP analyzed 186 honey samples. PDP detected 6 different pesticide residues in the honey samples. All residue detections were much lower than the established tolerances.

Action levels (ALs) are shown in this appendix, where applicable, and denote Action Level values established by FDA. Under the FQPA, responsibility for establishing tolerances in lieu of action levels has been transferred to EPA. In the interim, action levels are used.

PDP reports tolerance violations to the Food and Drug Administration (FDA) as part of an interagency Memorandum of Understanding between the U.S. Department of Agriculture and FDA. Residues reported to FDA are shown in the "Pesticide/Commodity" column to the right of the commodity and are annotated as "X" (if the residue exceeded the established tolerance) or "V" [if the residue did not have a tolerance listed in the Code of Federal Regulations (CFR), Title 40, Part 180]. In both cases, these annotations are followed by a number indicating the number of samples reported to FDA.

EPA tolerances as published in 40 CFR Part 180 are expressed in parts per million (ppm). Because honey residues are expressed in parts per billion (ppb), EPA Tolerances have been multiplied by a factor of 1,000 as a basis for comparison using a single scale. There is no intention to imply any more exactness in the value than that originally expressed by EPA.

APPENDIX D. DISTRIBUTION OF RESIDUES BY PESTICIDE IN HONEY

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Acephate	I	186				50 ^	20
Acetamiprid	I	186				40 ^	NT
Acetochlor	H	186				10 ^	NT
Alachlor	H	186				10 ^	NT
Aldicarb	I	186				4.0 ^	NT
Aldicarb sulfone	IM	186				15 ^	NT
Aldicarb sulfoxide	IM	186				20 ^	NT
Aldrin	I	186				10 ^	NT
Allethrin	I	186				10 ^	NT
Amicarbazone	H	186				30 ^	NT
Amitraz	I	186				4.0 ^	1000
Atrazine	H	186				6.0 ^	NT
Azinphos methyl	I	186				6.0 ^	NT
Azoxystrobin	F	186				2.0 ^	NT
Bendiocarb	I	186				2.0 ^	NT
Benoxacor	S	186				4.0 ^	10
BHC alpha	I	186				4.0 ^	NT
Bifenazate	A	186				20 ^	NT
Bifenthrin	I	186				2.0 ^	50
Boscalid	F	186				4.0 ^	NT
Bromuconazole	F	186				20 ^	NT
Buprofezin	I	186				20 ^	NT
Captan	F	186				10 ^	NT
Carbaryl	I	186				30 ^	NT
Carbendazim (MBC)	F	186				5.0 ^	NT
Carbofuran	I	186				5.0 ^	NT
Carboxin	F	186				4.0 ^	NT
Carfentrazone ethyl	H	186				1.0 ^	NT
Chlorfenapyr	I	186				1.0 ^	10
Chlorfenvinphos total	I	186				6.0 ^	NT
Chlorothalonil	F	186				2.0 ^	NT
Chlorpropham	H	186				40 ^	NT
Chlorpyrifos	I	186				1.0 ^	100
Chlorpyrifos methyl	I	186				1.0 ^	NT
Clofentezine	I	186				100 ^	NT
Clothianidin	I	186				20 ^	NT
Coumaphos	I	186	83	44.6	1.0 - 11.8	1.0 ^	150

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Coumaphos oxygen analog	IM	186				5.0 ^	150
Cyfluthrin	I	186				4.0 ^	50
Cyhalothrin, Lambda	I	186				1.0 ^	10
Cypermethrin	I	186				4.0 ^	50
Cyphenothrin	I	186				20 ^	NT
Cyprodinil	F	186				16 ^	NT
DDD p,p'	IM	186				4.0 ^	NT
DDE p,p'	IM	186				2.0 ^	NT
DDT p,p'	I	186				4.0 ^	NT
DEF (Tribufos)	H	186				2.0 ^	NT
Deltamethrin (includes parent Tralomethrin)	I	186				50 ^	50
Diazinon	I	186				1.0 ^	NT
4,4-dibromobenzophenone	A	186				4.0 ^	NT
Dichlorvos (DDVP)	I	186				10 ^	500
Dicloran (V-1)	F	186	1	0.5	1.0 ^	1.0 ^	NT
Dicofol p,p' (V-3)	I	186	3	1.6	1.3 - 3.6	1.0 ^	NT
Dieldrin	I	186				10 ^	NT
Difenoconazole	F	186				10 ^	NT
Diflubenzuron	I	186				100 ^	NT
Dimethenamid	H	186				10 ^	NT
Dimethoate	I	186				20 ^	NT
Dimethomorph	F	186				20 ^	NT
2,4-dimethyl aniline (2,4 DMA)	I	186				50 ^	NT
2,4-dimethylphenyl formamide (2,4-DMPF)	IM	186	8	4.3	4.2 - 27.5	4.0 ^	1000
Dinotefuran	I	186				30 ^	NT
Diphenamid	H	186				1.0 ^	NT
Endosulfan I	I	186				2.0 ^	NT
Endosulfan II	IM	186				2.0 ^	NT
Endosulfan sulfate	IM	186				2.0 ^	NT
Endrin	I	186				10 ^	NT
Epoxiconazole	F	186				1.0 ^	NT
Esfenvalerate+Fenvalerate Total	I	186				2.0 ^	50
Ethion	I	186				10 ^	NT
Ethofumesate	H	186				5.0 ^	NT
Etoxazole	A	186				1.0 ^	NT
Etridiazole	F	186				10 ^	NT
Famoxadone	F	186				20 ^	NT

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Fenamidone	F	186				10 ^	NT
Fenbuconazole	F	186				10 ^	NT
Fenhexamid	F	186				6.0 ^	NT
Fenoxaprop ethyl	H	186				6.0 ^	NT
Fenpropathrin	I	186				10 ^	NT
Fenpyroximate	A	186				5.0 ^	100
Fenthion	I	186				10 ^	NT
Fipronil	I	186				10 ^	NT
Fludioxonil	F	186				100 ^	NT
Fluoxastrobin	F	186				4.0 ^	NT
Fluridone	H	186				50 ^	NT
Flutolanil	F	186				4.0 ^	NT
Fluvalinate	I	186	19	10.2	1.0 - 6.7	1.0 ^	50
Heptachlor	I	186				4.0 ^	NT
Heptachlor epoxide	IM	186				10 ^	NT
Hexachlorobenzene (HCB)	FM	186				1.0 ^	NT
Hexythiazox	I	186				30 ^	NT
Hydroprene	R	186				10 ^	200
3-Hydroxycarbofuran	IM	186				4.0 ^	NT
Imazalil	F	186				5.0 ^	NT
Imidacloprid	I	186				20 ^	NT
Indoxacarb	I	186				30 ^	NT
Iprodione	F	186				20 ^	NT
Lindane (BHC gamma)	I	186				4.0 ^	NT
Linuron	H	186				100 ^	NT
Malathion	I	186				4.0 ^	NT
Metalaxyl	F	186				2.0 ^	NT
Methamidophos	I	186				20 ^	20
Methidathion	I	186				10 ^	NT
Methomyl	I	186				10 ^	NT
Methoxyfenozide	I	186				2.0 ^	NT
Metolachlor	H	186				6.0 ^	NT
Metribuzin	H	186				1.0 ^	NT
MGK-264	I	186				10 ^	10000
MGK-326 (dipropyl isocinchomeronate)	I	186				10 ^	NT
Myclobutanil	F	186				15 ^	NT
1-Naphthol	IM	186				10 ^	NT
Norflurazon	H	186				6.0 ^	NT

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Oxamyl	I	186				5.0 ^	NT
Oxyfluorfen	H	186				1.0 ^	NT
Parathion methyl	I	186				2.0 ^	NT
Pendimethalin	H	186				6.0 ^	NT
Permethrin Total	I	186				10 ^	NT
Phenothrin	I	186				10 ^	NT
Phorate	I	186				10 ^	NT
Phosalone	I	186				10 ^	NT
Phosmet	I	186				10 ^	NT
Piperonyl butoxide	I	186				6.0 ^	NT
Pirimiphos methyl	I	186				4.0 ^	NT
Prallethrin	I	186				4.0 ^	1000
Profenofos	I	186				10 ^	NT
Pronamide	H	186				1.0 ^	NT
Propachlor	H	186				10 ^	NT
Propanil	H	186				10 ^	NT
Propargite	I	186				10 ^	NT
Propazine	H	186				4.0 ^	NT
Propetamphos	I	186				4.0 ^	100
Propham	H	186				20 ^	NT
Propiconazole	F	186				10 ^	NT
Pyraclostrobin	F	186				15 ^	NT
Pyrethrins	I	186				50 ^	1000
Pyridaben	I	186				1.0 ^	NT
Pyrimethanil	F	186				3.0 ^	NT
Pyriproxyfen	I	186				1.0 ^	100
Quinoxyfen	F	186				10 ^	NT
Quintozene (PCNB)	F	186				1.0 ^	NT
Resmethrin	I	186				10 ^	3000
Sethoxydim	H	186				8.0 ^	NT
Simazine	H	186				10 ^	NT
Spirodiclofen	A	186				1.0 ^	NT
Spiromesifen Total (parent + enol metabolite)	I	186				10 ^	NT
Tebuconazole	F	186				8.0 ^	NT
Tebufenozide	I	186				5.0 ^	NT
Tebuthiuron	H	186				2.0 ^	NT
Tefluthrin	I	186				1.0 ^	NT
Tetrachlorvinphos	I	186				4.0 ^	NT

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Tetraconazole	F	186				6.0 ^	NT
Tetradifon	I	186				1.0 ^	NT
Tetrahydrophthalimide (THPI)	FM	186				50 ^	NT
Tetramethrin	I	186				10 ^	NT
Thiabendazole	F	186				4.0 ^	NT
Thiacloprid	I	186				8.0 ^	NT
Thiamethoxam	I	186				20 ^	NT
Triadimefon	F	186				2.0 ^	NT
Triadimenol	F	186				45 ^	NT
Trifloxystrobin	F	186				2.0 ^	NT
Triflumizole	F	186				10 ^	NT
Trifluralin	H	186				1.0 ^	NT
Triticonazole	F	186				10 ^	NT
Vinclozolin (V-2)	F	186	2	1.1	10.6 - 10.7	1.0 ^	NT

Many of the listed tolerances are the sum of a parent compound and metabolite(s)/isomer(s). The reader is advised to refer to EPA for the complete listing of compounds in tolerance expressions.

NOTES

* = EPA Tolerances have been multiplied by a factor of 1000 as a basis for comparison using a single scale. There is no intention to imply any more exactness in the value than that originally expressed by EPA.

^ = Only one distinct detected concentration or LOD value was reported for the pair.

NT = No tolerance level was set for that pesticide/commodity pair.

(V) = Residue was found where no tolerance was established by EPA. Following "V" are the number of occurrences.

Pesticide Types:

A = Acaricide

F = Fungicide, FM = Fungicide Metabolite

H = Herbicide

I = Insecticide, IM = Insecticide Metabolite

R = Insect Growth Regulator

S = Herbicide Safener

Appendix D

Distribution of Residues by Pesticide in Honey

Appendix D shows residue detections for all compounds tested in honey, including range of values detected, range of Limits of Detection (LODs), and U.S. Environmental Protection Agency (EPA) tolerance references for each pair. The EPA tolerances cited in this summary and Appendices apply to 2008 and not to the current year. There may be instances where tolerances may have been recently set or revoked that would have an effect on whether a residue is violative or not.

In 2008, the Pesticide Data Program (PDP) analyzed 558 honey samples. PDP detected 12 different pesticide residues in the honey samples. All residue detections were lower than the established tolerances for those compounds with established tolerances. Based on PDP results, EPA has concluded that pesticide concentrations in honey did not raise any concerns for human consumption since all detections were low in concentration and therefore, dietary exposure based on honey would be low.

PDP reports tolerance violations to the U.S. Food and Drug Administration (FDA) as part of an interagency Memorandum of Understanding between the U.S. Department of Agriculture and FDA. Residues reported to FDA are shown in the "Pesticide" column to the right of the pesticide name and are annotated as "X" (if the residue exceeded the established tolerance) or "V" [if the residue did not have a tolerance listed in the *Code of Federal Regulations (CFR), Title 40, Part 180]*. In both cases, these annotations are followed by a number indicating the number of samples reported to FDA.

EPA tolerances as published in *40 CFR Part 180* are expressed in parts per million (ppm). Because honey residues are expressed in parts per billion (ppb), EPA tolerances have been multiplied by a factor of 1,000 as a basis for comparison using a single scale. There is no intention to imply any more exactness in the value than that originally expressed by EPA.

APPENDIX D. DISTRIBUTION OF RESIDUES BY PESTICIDE IN HONEY

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Acephate	I	558				50 ^	20
Acetamiprid	I	558				40 ^	NT
Acetochlor	H	558				10 ^	NT
Alachlor	H	558				10 ^	NT
Aldicarb	I	558				4.0 ^	NT
Aldicarb sulfone	IM	558				15 ^	NT
Aldicarb sulfoxide	IM	558				20 ^	NT
Aldrin	I	558				10 ^	NT
Allethrin	I	558				10 ^	NT
Amicarbazone	H	558				30 ^	NT
Amitraz	I	558				4.0 ^	NT
Atrazine	H	558				6.0 ^	NT
Azinphos methyl	I	558				6.0 ^	NT
Azoxystrobin (V-3)	F	558	3	0.5	3.3 - 4.0	2.0 ^	NT
Bendiocarb	I	558				2.0 ^	NT
Benoxacor	S	558				4.0 ^	NT
BHC alpha	I	558				4.0 ^	NT
Bifenazate	A	558				20 ^	NT
Bifenthrin	I	558				2.0 ^	50
Boscalid	F	558				4.0 ^	NT
Bromuconazole	F	558				20 ^	NT
Buprofezin	I	558				20 ^	NT
Captan	F	558				10 ^	NT
Carbaryl	I	558				30 ^	NT
Carbendazim (V-1)	F	558	1	0.2	27.3 ^	5.0 ^	NT
Carbofuran	I	558				5.0 ^	NT
Carboxin	F	558				4.0 ^	NT
Carfentrazone ethyl	H	558				1.0 ^	NT
Chlorfenapyr	I	558				1.0 ^	10
Chlorfenvinphos total	I	558				6.0 ^	NT
Chlorothalonil	F	558				2.0 ^	NT
Chlorpropham	H	558				40 ^	NT
Chlorpyrifos	I	558	1	0.2	1.3 ^	1.0 ^	100
Chlorpyrifos methyl	I	558				1.0 ^	NT
Clofentezine	I	558				100 ^	NT
Clothianidin	I	558				20 ^	NT
Coumaphos	I	558	180	32.3	1.0 - 8.2	1.0 ^	150

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Coumaphos oxygen analog	IM	558				5.0 ^	150
Cyfluthrin	I	558				4.0 ^	50
Cyhalothrin, Lambda	I	558				1.0 ^	10
Cypermethrin	I	558				4.0 ^	50
Cyphenothrin	I	558				20 ^	NT
Cyprodinil	F	558				16 ^	NT
DDD p,p'	IM	558				4.0 ^	NT
DDE p,p'	IM	558				2.0 ^	NT
DDT p,p'	I	558				4.0 ^	NT
DEF (Tribufos)	H	558				2.0 ^	NT
Deltamethrin (includes parent Tralomethrin)	I	558				50 ^	50
Diazinon	I	558				1.0 ^	NT
4,4-dibromobenzophenone	A	558				4.0 ^	NT
Dichlorvos (DDVP)	I	558				10 ^	500
Dicloran (V-2)	F	558	2	0.4	1.1 - 1.6	1.0 ^	NT
Dicofol p,p' (V-32)	I	558	32	5.7	1.0 - 90	1.0 ^	NT
Dieldrin	I	558				10 ^	NT
Difenoconazole	F	558				10 ^	NT
Diflubenzuron	I	558				100 ^	NT
Dimethenamid	H	558				10 ^	NT
Dimethoate	I	558				20 ^	NT
Dimethomorph	F	558				20 ^	NT
2,4-dimethyl aniline (2,4 DMA)	I	558				50 ^	NT
2,4-dimethylphenyl formamide (2,4-DMPF)	IM	558	73	13.1	4.1 - 85.1	4.0 ^	1000
Dinotefuran	I	558				30 ^	NT
Diphenamid	H	558				1.0 ^	NT
Endosulfan I	I	558				2.0 ^	NT
Endosulfan II	IM	558				2.0 ^	NT
Endosulfan sulfate	IM	558				2.0 ^	NT
Endrin	I	558				10 ^	NT
Epoxiconazole	F	558				1.0 ^	NT
Esfenvalerate+Fenvalerate Total	I	558				2.0 ^	50
Ethion	I	558				10 ^	NT
Ethofumesate	H	558				5.0 ^	NT
Etoxazole	A	558				1.0 ^	NT
Etridiazole	F	558				10 ^	NT
Famoxadone	F	558				20 ^	NT
Fenamidone	F	558				10 ^	NT

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Fenbuconazole	F	558				10 ^	NT
Fenhexamid	F	558				6.0 ^	NT
Fenoxaprop ethyl	H	558				6.0 ^	NT
Fenpropathrin	I	558				10 ^	NT
Fenpyroximate	A	558				5.0 ^	100
Fenthion	I	558				10 ^	NT
Fipronil	I	558				10 ^	NT
Fludioxonil	F	558				100 ^	NT
Fluoxastrobin	F	558				4.0 ^	NT
Fluridone	H	558				50 ^	NT
Flutolanil	F	558				4.0 ^	NT
Fluvalinate	I	558	69	12.4	1.0 - 14.5	1.0 ^	50
Heptachlor	I	558				4.0 ^	NT
Heptachlor epoxide	IM	558				10 ^	NT
Hexachlorobenzene (HCB)	FM	558				1.0 ^	NT
Hexythiazox	I	558				30 ^	NT
Hydroprene	R	558				10 ^	200
3-Hydroxycarbofuran	IM	558				4.0 ^	NT
Imazalil	F	558				5.0 ^	NT
Imidacloprid	I	558				20 ^	NT
Indoxacarb	I	558				30 ^	NT
Iprodione	F	558				20 ^	NT
Lindane (BHC gamma)	I	558				4.0 ^	NT
Linuron	H	558				100 ^	NT
Malathion	I	558				4.0 ^	NT
Metalaxyl	F	558				2.0 ^	NT
Methamidophos	I	558				20 ^	20
Methidathion	I	558				10 ^	NT
Methomyl	I	558				10 ^	NT
Methoxyfenozide (V-1)	I	558	1	0.2	2.8 ^	2.0 ^	NT
Metolachlor	H	558				6.0 ^	NT
Metribuzin	H	558				1.0 ^	NT
MGK-264	I	558				10 ^	10000
MGK-326 (dipropyl isocinchomeronate)	I	558				10 ^	NT
Myclobutanil	F	558				15 ^	NT
1-Naphthol	IM	558				10 ^	NT
Norflurazon	H	558				6.0 ^	NT
Oxamyl	I	558				5.0 ^	NT
Oxyfluorfen	H	558				1.0 ^	NT

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Parathion methyl	I	558				2.0 ^	NT
Pendimethalin	H	558				6.0 ^	NT
Permethrin Total (V-1)	I	558	1	0.2	11 ^	10 ^	NT
Phenothrin	I	558				10 ^	NT
Phorate	I	558				10 ^	NT
Phosalone	I	558				10 ^	NT
Phosmet	I	558				10 ^	NT
Piperonyl butoxide	I	558	10	1.8	6.3 - 9.6	6.0 ^	10000
Pirimiphos methyl	I	558				4.0 ^	NT
Prallethrin	I	558				4.0 ^	1000
Profenofos	I	558				10 ^	NT
Pronamide	H	558				1.0 ^	NT
Propachlor	H	558				10 ^	NT
Propanil	H	558				10 ^	NT
Propargite	I	558				10 ^	NT
Propazine	H	558				4.0 ^	NT
Propetamphos	I	558				4.0 ^	100
Propham	H	558				20 ^	NT
Propiconazole	F	558				10 ^	NT
Pyraclostrobin	F	558				15 ^	NT
Pyrethrins	I	558				50 ^	1000
Pyridaben	I	558				1.0 ^	NT
Pyrimethanil	F	558				3.0 ^	NT
Pyriproxyfen	I	558				1.0 ^	100
Quinoxyfen	F	558				10 ^	NT
Quintozene (PCNB)	F	558				1.0 ^	NT
Resmethrin	I	558				10 ^	3000
Sethoxydim	H	558				8.0 ^	NT
Simazine	H	558				10 ^	NT
Spirodiclofen	A	558				1.0 ^	NT
Spiromesifen Total (parent + enol metabolite)	I	558				10 ^	NT
Tebuconazole	F	558				8.0 ^	NT
Tebufenozide	I	558				5.0 ^	NT
Tebuthiuron	H	558				2.0 ^	NT
Tefluthrin	I	558				1.0 ^	NT
Tetrachlorvinphos	I	558				4.0 ^	NT
Tetraconazole	F	558				6.0 ^	NT
Tetradifon	I	558				1.0 ^	NT

Pesticide	Pest. Type	Number of Samples	Samples with Detections	% of Samples w/ Detects	Range of Values Detected, ppb	Range of LODs, ppb	EPA Tolerance Level, ppb*
Tetrahydrophthalimide (THPI)	FM	558				50 ^	NT
Tetramethrin	I	558				10 ^	NT
Thiabendazole	F	558				4.0 ^	NT
Thiacloprid	I	558				8.0 ^	NT
Thiamethoxam	I	558				20 ^	NT
Triadimefon	F	558				2.0 ^	NT
Triadimenol	F	558				45 ^	NT
Trifloxystrobin	F	558				2.0 ^	NT
Triflumizole	F	558				10 ^	NT
Trifluralin	H	558				1.0 ^	NT
Triticonazole	F	558				10 ^	NT
Vinclozolin (V-3)	F	558	3	0.5	1.3 - 2.1	1.0 ^	NT

Many of the listed tolerances are the sum of a parent compound and metabolite(s)/isomer(s). The reader is advised to refer to EPA for the complete listing of compounds in tolerance expressions. The cited tolerances apply to 2008 and not to the current year. There may be instances where a tolerance was recently set or revoked that would have an effect on whether a residue is violative or not.

NOTES

* = EPA tolerances have been multiplied by a factor of 1,000 as a basis for comparison using a single scale. There is no intention to imply any more exactness in the value than that originally expressed by EPA.

^ = Only one distinct detected concentration or LOD value was reported for the pair.

NT = No tolerance level was set for that pesticide/commodity pair.

(V) = Residue was found where no tolerance was established by EPA. Following "V" are the number of occurrences.

Pesticide Types:

A = Acaricide

F = Fungicide, FM = Fungicide Metabolite

H = Herbicide

I = Insecticide, IM = Insecticide Metabolite

R = Insect Growth Regulator

S = Herbicide Safener

Table 1. Summary of the attractiveness to *Apis* and non-*Apis* bees of crops grown in the U.S., whether crop requires bee pollination and if so, whether managed pollinators are used.

Also summarized is the bearing acreage of the crop, the extent to which the crop is used in seed production and whether the crop is harvested prior to bloom. The degree to which pollen and nectar are attractive is listed using a scale where "-" = not attractive, "+" = attractive under certain conditions, and "++" = high attractiveness; entry "N/AV" specifies when crop-specific data are unavailable; entry "N/AP" specifies when crop-specific data are not applicable.

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Alfalfa	*Medicago sativa*	+	++	+	++ Alfalfa leafcutting bee, Alkali bee	Yes	Yes	1	17,763,000	2011: 6600 acres	Yes	Also grown for seed on a small % of acreage where both Megachilidae and Apis are contracted; alfalfa grown for forage harvested at 10% bloom.
Almonds	*Prunus amygdalus*; *P. communis*; *Amygdalus communis*	++	+	+	+*Osmia*	Yes	Yes	1	780,000		No	
Anise, badian, fennel, corian, juniper berries	anise (*Pimpinella anisum*); badian or star anise (*Illicium verum*); caraway (*Carum carvi*); coriander (*Coriandrum sativum*); cumin (*Cuminum cyminum*); fennel (*Foeniculum vulgare*); juniper berries (*Juniperus communis*)	+	+	+	+	Yes (not juniper berries)	No	2	N/AV		No	

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, 2015

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Apples	*Malus pumila*; *M. sylvestris*; *M. communis*; *Pyrus malus*	++	+	+	++*Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda*	Yes	Yes	1	327,800		No	
Apricots	*Prunus armeniaca*	++	++	++	+*Osmia*	Yes	Yes	3	12,150		No	
Artichokes	*Cynara scolymus*	+	+	+	+	Yes	No	3,4, 81	7,000		Yes	
Asparagus	*Asparagus officinalis*	+	+	N/AV	N/AV	Yes	Yes	1	24,500		Yes	Requires pollination only when grown for seed; small % of acreage
Avocados	*Persea americana*	+	+	N/AV	+	Yes	Yes	1	59,950		No	
Bananas	*Musa sapientum*; *M. cavendishii*; *M. nana*	-	+	-	-	No	No	5	1,000		No	
Barley	*Hordeum* spp.	-	-	-	-	No	No	3	3,000,000		No	Wind pollinated
Beans	*Phaseolus* spp.	+	+	+	N/AV	No	No	3	77,200		No	Acreage is for snapbeans
Blueberries	fruits of the genus *Vaccinium*	+	+	++	++*Andrena, Colletes, Osmia, Anthophora, Xylocopa*	Yes	Yes	1	77,700		No	Acreage is only for cultivated blueberries; *Apis M.* and Megachilidae used in commercial pollination.
Broad beans, horse beans, dry	*Vicia faba*	++	++	++	+*Anthophora, Eucera, Megachile, Xylocopa*	Yes		5	1,311,300		No	
Buckwheat	*Fagopyrum esculentum*	+	++	+	+	Yes	Yes	5, 73	33,678		No	

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Cabbages and other brassica	Chinese, mustard cabbage, pak-choi (*Brassica chinensis*); white, red, Savoy cabbage, Brussels sprouts, collards, kale and kohlrabi (*Brassica oleracea* all varieties except *botrytis*)	++	++	+	+	Yes	Yes	1	Cabbage 60,180 (Annual); Brussels sprouts 7,569 (Census); Kale 6,256 (Census); Collards 12,542 (Census)		Yes	Requires pollination only when grown for seed. Small % of acreage
Carobs	*Ceratonia siliqua*, Carob tree, locust bean	+	+	+	+	Yes	No	49, 74				Flowers visited mainly by flies and wasps
Carrots	*Daucus carota*	+	+	+	+ *Megachile rotundata*	Yes	Yes	1, 3	71,400 Fresh Market; 13,310 Processing	2012: 4941 acres	Yes	Requires pollination only when grown for seed. Small % of acreage
Castor oil seed	*Ricinus communis*	+	-	N/AV	N/AV			EFSA	N/AV	Yes	No	
Cauliflowers and broccoli	*Brassica oleracea* var. *botrytis*, subvarieties *cauliflora* and *cymosa*, includes headed broccoli	++	++	+	+ *Andrenidae, Nomadidae, Megachilidae*	Yes	Yes	5	163,730 Fresh market and processing		Yes	Requires pollination only when grown for seed; small % of acreage
Cherries	Mazzard, sweet cherry (*Prunus avium*; *Cerasus avium*); hard-fleshed cherry (var. *duracina*); heart cherry (var. *juliana*)	++	+	+	++ *Osmia*	Yes	Yes	1	86,790 Sweet; 36,500 Tart		No	
Chestnuts	*Castanea* spp.: *C. vesca*; *C. vulgaris*; *C. sativa*.	++	++	+	+	Yes	Yes	3	3,784			

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Chick peas	Chickpea, Bengal gram, garbanzos (*Cicer arietinum*)	+	++	+	+ *Osmia, Megachile*	No	No	72	213,600; Note: Included in All Dry Bean Acres			Self-pollinated
Chicory roots	*Cichorium intybus* subsp. *sativum*	+	+	N/AV	+*Andrena, Anthidium, Halictus, Osmia*	Yes	N/AV	EFSA, 3	N/AV		Yes	
Chillies and peppers	Red and cayenne pepper, paprika, chillies (*Capsicum frutescens*; *C. annuum*); allspice, Jamaica pepper (*Pimenta officinalis*)	+	-	++	+	Yes	No	1	71,200 Chile and Bell			May be grown in glasshouses, with bumble bees for pollination
Clover for forage and silage	*Trifolium* spp. Various species grown for pasture, green fodder or silage	++	++	+	++ *Megachile, Osmia, Andrena, Anthidium*	Yes	Yes	1,5, 89, 102, 103	28,506 White, Red and Crimson		Yes	Requires pollination only when grown for seed; small % of acreage
Coffee, green	*Coffea* spp. (*arabica, robusta*, *liberica*)	+	-	N/AV	+	Yes	No	5	7300	Yes	No	Acreage related to all coffee, not specific to green coffee
Corn	*Zea mays*	+	-	+	+	No	No	3	87,668,000			Wind pollinated, but can be visited during pollen shedding
Cow peas	Cowpea, blackeye pea/ bean (*Vigna unguiculata*)	-	+[3]	+	+	Yes	N/AV	11	39,100 Blackeye Peas, Included with All Dry Beans		No	
Cranberries	American cranberry (*Vaccinium macrocarpon*)	+	+	++	++*Andrena, Agapostemon, Melitta, Megachile*	Yes	Yes	1	40,300		No	

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, 2015

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Cucumbers and gherkins	*Cucumis sativus*	+	+	+	+ *Melissodes Andrena*	Yes	Yes	1	40,060 Fresh; 82,100 for Pickles	Yes		Small seed acreage
Currants	Black (*Ribes nigrum*); red and white (*R. rubrum*)	-	+	++	+ *Anthophora*	Yes	No	5	580 Total		No	
Dates	*Phoenix dactylifera*	+	+	N/AV	N/AV	No	No	3	8,400		No	Wind pollinated
Eggplants	*Solanum melongena*	-	-	++	+	Yes	No	5	5,004		No	Requires pollination only when grown for seed; small % of acreage
Elder	*Sambucus nigra*	+	+	+	+	No	No	6	N/AV			
Figs	*Ficus carica*	-	-	-	-	No	No	5	8,600		No	Wasp pollinated
Garlic	*Allium sativum*	+	+	N/AV	*+Halictus, Osmia*	Yes	No	3	23,900		Yes	Requires pollination only when grown for seed; small % of acreage
Gooseberry	*Ribes grossularia*	-	+	++	+	Yes	No	5	N/AV		No	Little production in US
Grapefruit (inc. pomelos)	*Citrus maxima; C. grandis; C. paradisi*	++	++	+	N/AV	No	No	3, 9	73,300 (no pomelos)		No	
Grapes	*Vitis vinifera*	+	-	-	-	No	No	5	962,100		No	Wind pollinated

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Grasses for forage; Sil	Including inter alia: bent, redtop, fiorin grass (*Agrostis* spp.); bluegrass (*Poa* spp.); Columbus grass (*Sorghum almum*); fescue (*Festuca* spp.); Napier, elephant grass (*Pennisetum purpureum*); orchard grass (*Dactylis glomerata*); Rhodes grass (*Chloris gayana*); *Phleum, Agropyron, Elymus, Phalaris, Koeleria, Stipa, Danthonia, Deschampsia, Bromus, Trisetum, Calamagrostis, Carex and Juncus*	+	-	-	-	No	No	5	35,328,000		Yes	Wind pollinated, source of pollen only when no other forage sources are available
Groundnuts, with shell, peanuts	*Arachis hypogaea*	+	N/AV	+	+ *Lasioglossum, Megachile, Anthidium, Nomia*	N/AV	N/AV	EFSA	1,042,000			
Hazelnuts, with shell (filberts)	*Corylus avellana*	+	-	-	-	No	No	50	29,000			
Hemp	*Cannabis sativa*	+	-	+	N/AV	No	No	51	N/AV			Wind pollinated
Hops	*Humulus lupulus*	+	-	-	-	No	No	7, 82	35,224			
Kiwi fruit	*Actinidia chinensis*	+	+	+	+	Yes	Yes	1	4,200			

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Leeks, other alliaceous vegetables	Leeks (*Allium porrum*); chives (*A. schoenoprasum*); other alliac	+	++	+	+ *Osmia, Hoplitis*	Yes	No	3, 5	N/AV		Yes	Requires pollination only when grown for seed; small % of acreage
Leguminous for silage	Including inter alia: birdsfoot trefoil (*Lotus corniculatus*); lespedeza (*Lespedeza* spp.); kudzu (*Pueraria lobata*); sesbania (*Sesbania* spp.); sainfoin, esparcette (*Onobrychis sativa*); sulla (*Hedysarum coronarium*)	+	++	++	++ *Anthidium, Anthophora, Lasioglossum, Megachile, Osmia, Xylocopa*	Yes	Yes	3, 8, 102, 103	Birdsfoot - Not Published; 3,219 Lespedeza			Trefoil is valuable honey plant for beekeepers. Potential use of the *Megachilidae* to pollinate sweet clover and sanfoin
Leguminous vegetables	*Vicia faba*	++	++	++	+ *Anthophora, Eucra, Megachile*	Yes	No	1	N/AV		No	
Lemons/ limes	Lemon (*Citrus limon*); sour lime (*C. aurantifolia*); sweet lime (*C. limetta*)	++	++	N/AV	+	No	No	5	55,000 Lemons (Annual) 820 Limes (Census)			
Lentils	*Lens esculenta*; *Ervum lens*	+	+[3]	-	+ *Megachile*	No	No	52	347,000			
Lettuce	*Lactuca sativa*	+	+	+	+	No	No	3, 5	259,100 Head, Leaf and Romaine		Yes	Self-pollinating
Linseed	*Linum usitatissimum* Flaxseed.	-	-	-	-	No	Yes	90	N/AV			Extensively grown in the Dakotas and the Canadian Prairies.

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Lupins	*Lupinus alba*, *L. angustifolia*, *L. luteus*.	+	-	++	+	Yes	No	91	N/AV			Requires pollination only when grown for seed; small % of acreage
Melonseed	*Cucumis melo*, includes seeds of other Cucurbitaceae	+	+	+	+ *Ceratina, Peponapis, Melissodes, Agapostemon*	Yes	Yes	5	N/AV		No	
Mushrooms and truffles	Edible mushrooms	N/AP	N/AP	N/AP	N/AP	No	No	40				Produced indoors in the dark, no bee pollination required
Mustard seed	White mustard (*Brassica alba; B. hirta*; *Sinapis alba*); black mustard (*Brassica nigra*; *Sinapis nigra*) *Brassica juncea*	++	++	+	+	Yes	N/AV	5		43,400	No	*B. juncea* extensively grown on Great Plains and southern Canadian prairies; is $^{2}/_{3}$ self fertile and $^{1}/_{3}$ out crossing, so bees partially required
Oat	*Avena* spp., mainly *Avena sativa*	-	-	-	-	No	No	3	1,030,000			Wind pollinated
Okra	*Abelmoschus esculentus*; *Hibiscus esculentus*	+	+	+	+	Yes	No	5	2,377			
Olives	*Olea europaea*	+	-	N/AV	N/AV	No	No	3	44,000			
Onions	*Allium cepa*	+	+	-	+ *Halictus, Nomia*	Yes	Yes	5	143,340	dry bulb: 2010: 73213 acres	Yes	Requires pollination only when grown for seed; small % of acreage
Oranges	Common, sweet orange (*Citrus sinensis*); bitter orange (*C. aurantium*)	++	++	+	+ *Andrena, Xylocopa*	No	Yes	9	613,000			Variable among orange cultivars; honey bees brought to groves for orange blossom honey

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Peaches/ nectarines	*Prunus persica*; *Amygdalus persica*; *Persica laevis*	+	+	+	+ *Osmia*	Yes	Yes	1	112,880 Peaches; 26,400 Nectarines			
Pears	*Pyrus communis*	+	+	+	+ *Osmia, Andrena*	Yes	Yes	1	54,400			
Peas	Garden pea (*Pisum sativum*); field pea (*P. arvense*)	+	+	+	+ *Eucera, Xylocopa*	No	No	7	797,000	2013; 406 acres		
Peppermint	*Mentha* spp.: *M. piperita*	+	++	++	+	No	No	39	68,800			Peppermint oil is produced from vegetative growth, without flowering or seed production
Persimmons	*Diospyros kaki*; *D. virginiana*	+	+	+	+	Yes	No	5	4,968			
Pistachios	*Pistacia vera*	-	-	-	-	No	No	53	178,000			Wind pollinated
Plums and sloes	Greengage, mirabelle, damson (*Prunus domestica*); sloe (*P. spinosa*)	+	+	+	+ *Osmia, Anthophora*	Yes	Yes	1	82,780			
Poppy seed	*Papaver somniferum*	++	-	N/AV	N/AV	No	N/AV	EFSA, 92	N/AV			Mainly self fertile although cross pollination via insect, bees does occur
Potatoes	*Solanum tuberosum* Irish potato	-	-	+	+*Andrena*	Yes	No	3	1,052,000			Requires pollination only for breeding; small % of acreage
Pumpkins, squash and gourds	*Cucurbita* spp., includes marrows	+	+	++	+ *Agapostemon, Melissodes, Peponapis*	Yes	Yes	5	91,700 Pumpkins and Squash			

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Pyrethrum, dried	*Chrysanthemum cinerariifolium*	+	+	+	+	No	No	3, 81	N/AV			
Quinces	*Cydonia oblonga*; *C. vulgaris*; *C. japonica*	+	+	N/AV	N/AV	N/AV	N/AV	EFSA	N/AV			
Rapeseed (including canola)	*Brassica napus* var. *oleifera*	++	++	+	++ *Megachile*	Yes	Yes	1,3,5	1,264,500 Canola; 1,700 Rapeseed	2013: 1,500 acres		Managed bees needed for hybrid seed production
Raspberries	*Rubus idaeus*	+	+	++	+*Osmia, Anderna, Coletes, Halictus*	Yes	Yes	1	17,300			
Rice, paddy	*Oryza* spp., mainly *Oryza sativa*.	-	-	-	-	No	No	3	2,468,000			Wind pollinated
Rye	*Secale cereale*	-	-	-	-	No	No	3	278,000			Wind pollinated
Rye grass for forage and silage	Italian ryegrass (*Lolium multiflorum);* English, perennial ryegrass (*L. perenne*).	-	-	-	-	No	No	3	N/AV			Wind pollinated
Safflower seed	*Carthamus tinctorius*	+	+	N/AV	+	Yes	Yes	EFSA, 93	170,000			Safflower is basically self-pollinated, but bees or other insects are generally necessary for optimum fertilization and maximum yield
Seed cotton	*Gossypium* spp.	-	++[4]	+	+*Halictus, Anthophora, Xylocopa, Megachile, Nomia, Ptilothrix*	Yes	Yes	1	7,664,400			

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Serradella/ birdsfoot	*Ornithopus sativus*	+	++	N/AV	+ *Megachile*	Yes	N/AV	EFSA	N/AV			
Sesame seed	*Sesamum indicum*	+	++	N/AV	+	Yes	No	5	17,501			
Sorghum	*Sorghum* spp.: guinea corn (*S. guineense*); common, milo, feterita, kaffir corn (*S. vulgare*); durra, jowar, kaoliang (*S. dura*).	+	+	N/AV	+	No	No	3, 83	6,910,000 Grain and Silage			
Soybeans	*Glycine soja*	+	+	+	+	No	No	1	75,869,000			
Spices	Including inter alia: bay leaves (*Laurus nobilis*); dill seed (*Anethum graveolens*); fenugreek seed (*Trigonella foenum-graecum*); saffron (*Crocus sativus*); thyme (*Thymus vulgaris*); turmeric (*Curcuma longa*)	+	+	+	+	No	No	5	N/AV			Attractiveness depends on the species
Spinach	*Spinacia oleracea*	-	-	-	-	No	N/AV	EFSA	31,440		Yes	
Strawberries	*Fragaria* spp.	+	+	+	+*Andrena*, Halictids, *Osmia*	No	Yes	3	58,190			Not essential, but some growers add supplemental hives to compliment wind pollination
Sugar beet	*Beta vulgaris* var. *altissima*	-	+	N/AV	+	Yes	No	3	1,154,200		Yes	Requires pollination only for breeding; small % of acreage

Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, 2015

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Sugar cane	*Saccharum officinarum*	-	-	-	-	No	No	3	905,600	2013: 907 acres		Wind pollinated
Sunflower seed	*Helianthus annuus*	++	++	++	++*Halictus*, *Dieunomia*, *Megachile*, *Melissodes*, *Svastra*, *Xylocopa*	Yes	Yes	1	1,474,600	2013: 1,502,000 acres		
Sweet potatoes	*Ipomoea batatas*	+	+	+	+	Yes	No	5, 41, 78, 79	113,200			Propogated vegetatively, and requires pollination only for breeding. Small % of acreage
Tangerines, mandarins, clementines	Mandarin, tangerine (*Citrus reticulata*); clementine, satsuma (*C. unshiu*)	++	++	+	+*Andrena*, *Xylocopa*	Yes	Yes	9	52100 Tangerines and Mandarins			
Tobacco[5]	*Nicotiana tabacum*	+	-	+	+	No	No	44, 84	355,700		Yes	Typically deflowered as a standard production practice
Tomatoes	*Lycopersicon esculentum*	-	-	+	+	Yes	Yes	1	93,600 Fresh; 277,000 Processing			May be grown in glasshouses where bumble bees are needed for pollination
Triticale	*Triticum x Secale*	-	-	-	-	No	No	N/AV[6]	61,428			Triticale is a cross between wheat (Triticum) and rye (Secale), both wind pollinated
Turnips for fodder	*Brassica rapa* var. *rapifera*.	++	++	+	+	Yes	Yes	3	N/AV		Yes	Requires pollination only for breeding; small % of acreage

Crop	Description	HB Poll.[1]	HB Nec.[1]	Bumble Bees	Solitary Bees	Requires Bee Pollination	Uses Managed Pollinators	Ref No.	U.S. Bearing Acreage[2]	Seed Production[7]	Harvest Prior to Bloom	Notes
Vetches	Spring/common vetch (*Vicia sativa*).	++	+	++	++	Yes	No	42	3,441			
Viper's grass	*Scorzonera hispanica*	+	+	+	+	Yes	No	43	N/AV			*Note citation is not yet published*
Walnuts with shell	*Juglans* spp.: *J. regia*.	+	-	-	-	No	No	EFSA, 45	245,000			Wind pollinated
Watermelons	*Citrullus vulgaris*	+	+	+	+ *Agapostemon, Floridegus, Halictus, Hoplitus, Melissodes*	Yes	Yes	1	123,330			
Wheat	*Triticum* spp.: common (*T. aestivum*), durum (*T. durum*), spelt (*T. spelta*).	-	-	-	-	No	No	3	45,157,000			

[1] Major crops based on Appendix D in the EFSA bee risk assessment guidance document and their attractiveness to pollinating bees. The table also contains relevant agronomic information associated with each crop. The entry "N/AV" specifies when crop-specific data are unavailable. Where "EFSA" is listed as the reference for a specific crop in this table, the data from Appendix D in the EFSA bee risk assessment guidance are used as the sole source of information on attractiveness ratings as no additional data were identified.

[1] HB= honey bee; Pol = Pollen; Nec = Nectar

[2] Estimates from the Census of Agriculture have a 2012 harvested acreage date. NASS fruit estimates have a 2012 reference date and vegetables refer to 2013. Fruit estimates are in bearing acres. Field crops and specialty crops are reported in harvested acres. All Census estimates are reported in harvested acreage. N/AV = not available. Please refer to reference 48 in **Table 3** for the citation related to these data.

[3] Extra-floral nectaries

[4] Mainly on extra-floral nectaries

[5] Unmanufactured tobacco

[6] Extrapolation based on wheat and rye

[7] Seed production refers to crops grown to produce seeds intended for crop propagation rather than for human or livestock consumption